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Development of a New Nutrition Screening Tool for Use in an Acute Care Hospital

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Purpose: The objective of this study was to develop a new nutrition screening tool for quality improvement of the nutritional care process in an acute care hospital with a 2,000-bed capacity.

Methods: To evaluate the current nutrition screening tool, we first examined 435 patients (274 men, aged 59.0 ± 12.2 years). In the second step, the nutritional status of 387 patients (215 men, aged 57.5 ± 13.3 years) was assessed by the scored patient-generated subjective global assessment (PG-SGA) tool. Variables such as age, body mass index (BMI), plasma albumin concentration, weight change, food intake change, and disease severity were analyzed to select indices for developing a new Severance nutrition screening index (SNSI).

Results: The current nutrition screening tool had a poor correlation with the PG-SGA ($\kappa = 0.180$, $P < 0.0001$). The SNSI was calculated as follows: $\text{SNSI} = 1.5 \times \text{albumin} + 1.0 \times \text{BMI} + 4.5 \times \text{intake change} + 1.5 \times \text{weight loss}$ (for albumin < 3.0 , BMI < 20 , and decreased intake and weight loss $> 5\%$ of usual body weight). The SNSI showed a sensitivity of 90.5%, a specificity of 90.7%, and a high correlation ($\kappa = 0.628$, $P < 0.0001$) with the PG-SGA.

Conclusion: The SNSI appears to be a valid and useful nutrition screening tool to determine the nutritional risk of patients in acute care hospitals. (JKSPEN 2013;5(2): 82-88)

Key Words: Nutrition status, Nutritional index, Screening, Nutrition

중심 단어: 영양상태, 영양 지표, 검색, 영양

INTRODUCTION

The prevalence of malnutrition is reported to be up to 60%, depending on the type and composition of the patient group and the assessment methods used.¹ The ability of medical information on admission to accurately predict the risk for malnutrition-related complications is crucial in efforts to initiate early restorative medical nutritional therapy and to efficiently utilise nutritional care resources. The Joint Commission International has advised a nutrition assessment within 24 hours of admission to identify malnutrition as early as possible and to manage nutritional problems through adequate intervention. Nutritional screening tools vary with regard to the risk parameters used and their ability to determine nutritional risk. The nutrition risk index (NRI), malnutrition universal screening tool (MUST), nutritional risk screening 2002 (NRS 2002) and mini nutritional assessment (MNA) are the most popular screening tools and have been approved as being reliable.²

We have developed and employed an automated nutrition screening tool using percentage of current weight to ideal body weight (%IBW), serum albumin (s-alb), and severity of diagnosis. These data were automatically collected from the electronic medical records within 24 hours after hospital admission to screen the 200~250 new patients admitted daily since 2005. Although this method may be simple and rapid, it is limited in its ability to reflect nutritional stability and future risk of malnu-

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trition by excluding changes in recent weight and food intake.

As the first step in a quality improvement program for the nutritional care process in an acute care hospital with a 2,000-bed capacity, we conducted this study to evaluate and revise our current nutritional screening criteria and to validate the newly developed one.

MATERIALS AND METHODS

This study was prospectively conducted in two phases: 1) evaluation of the current nutrition screening tool and 2) development of a new nutritional screening index.

1. Subjects

To evaluate the current nutrition screening tool, we examined 435 patients who were admitted to Severance Hospital, a tertiary university hospital, for gastrointestinal cancer surgery between May 1 and September 30, 2011.³ In the second phase of the study, to develop a new Severance nutrition screening index (SNSI), we enrolled 387 patients who were admitted to 2 medical and 2 surgical wards during January 2012. We choose these 4 wards to determine whether SNSI could be applied to a broad spectrum of patient populations in this acute care university hospital. This study was approved by the institutional review board of Severance Hospital (IRB No. 4-2011-0016), and written informed consent was obtained from each patient before enrolment.

Table 1. Nutrition screening criteria

Parameter	High risk	Moderate risk	Low risk
%IBW	< 80	80~90	> 90
Serum albumin (g/dL)	≤ 2.7	2.7~3.1	≥ 3.2
Disease severity	Neoplasm Neurologic disease Gastrointestinal disease Kidney disease Liver disease Comatose status Gastrointestinal surgery	Cardiac disease Diabetes mellitus	Others

High risk group = more than 1 high risk parameter; moderate risk group = more than 1 moderate risk parameter or 1 high risk parameter and 1 moderate risk parameter; low risk group = the others; %IBW = percentage of current body weight to ideal body weight.

2. Evaluation of current nutrition screening tool

The current nutrition screening tool, used since 2005, divided the patients into 3 groups-low, moderate and high nutritional risk-using %IBW, s-alb and diagnosis (Table 1). For evaluation of the current nutrition screening tool, two clinical dieticians interviewed the patients and assessed their nutritional status using the scored patient-generated subjective global assessment (PG-SGA) within 24 hours after hospital admission. Data were collected regarding patient age, gender, diagnosis, height, weight, s-alb, and total lymphocyte count (TLC) from medical records. The scored PG-SGA assessment classified patients into well-nourished (PG-SGA stage A), mild to moderately malnourished (PG-SGA stage B), and severely malnourished (PG-SGA stage C) groups. We analyzed the consistency between the results from the current nutrition screening tool and PG-SGA using kappa (κ) statistics.

3. Development of the new nutrition screening index

To develop a new SNSI, we reviewed and compared the parameters of currently the advised and validated nutrition screening tool, i.e. NRS 2002, MNA, MUST, and scored PG-SGA.⁴ Two clinical dieticians collected information on patient age, gender, medical department, anthropometric measurements (height, weight, and body mass index [BMI]), s-alb, and TLC. Patients were interviewed within 24 hours after admission. Weight loss, intake change, and current intake were collected. The nutritional status of patients was evaluated using scored PG-SGA. Indicators for developing a SNSI were selected by multiple logistic regressions, which used the nutritional status from the PG-SGA as the dependent variable (well-nourished and mild to moderate malnutrition vs. severe malnutrition) and age, BMI, s-alb, weight change, changes in food intake, and disease severity were analysed as independent variables. Nutritional risk was determined by the best optimal cut-off point, which was the probability determined using Youden's index (sensitivity+specificity-1).

4. Statistical analysis

Data were analysed using IBM SPSS ver. 20.0 (IBM Co., Armonk, NY, USA). P-values of <0.05 were considered to be significant. Consistency between the PG-SGA and SNSI was evaluated with κ statistics. The value of κ varies from 0 to 1, a value of <0.2=poor, 0.2~0.4=fair, 0.4~0.6 moderate, 0.6~

0.8 substantial and >0.8 almost perfect concordance.⁵ Multiple logistic regression analysis was conducted to developing a SNSI. The validity of the SNSI was analysed by sensitivity, specificity, and negative and positive predictive values. The correlation between the SNSI and PG-SGA was assessed by the receiver operator characteristic (ROC) curve with the area under the curve. The area under the curve ranges from 0.5 to 1, a value of $0.9 \sim 1$ =excellent, $0.8 \sim 0.9$ =good, $0.7 \sim 0.8$ =fair, $0.6 \sim 0.7$ =poor, $0.5 \sim 0.6$ =fail.

RESULTS

In the evaluation phase, patients were 59.0 ± 23.2 years old, and 243 of the 435 patients (55.9%) were men. In the development phase, patients were 57.5 ± 13.3 years old, and 215 of the 387 patients (55.6%) were men. Ten patients (2.3%) in the evaluation phase were classified into the severe malnutrition group and 50 patients (10.4%) into the moderate malnutrition group, based on PG-SGA criteria. In the evaluation phase, there were no significant differences in age and s-alb between the well-nourished or moderately malnourished (SGA A and B) and the severely malnourished, whereas body weight and BMI were significantly lower in the severely malnourished group (SGA C) compared with the well-nourished or moderately malnourished patients (54.9 ± 10.9 kg vs 62.2 ± 10.3 kg, $P=0.035$; 20.0 ± 3.1 kg/m² vs 23.2 ± 2.9 kg/m², $P=0.006$) (Table 2).

Among the patients in the development phase, 185 patients were admitted to the medical department and 202 to the surgical department. The majority of the subjects were diagnosed with cancer ($n=309$, 79.8%) (Table 3). Forty-two patients

(10.9%) in the development phase were severely malnourished based on PG-SGA criteria. The prevalence of severe malnutrition did not differ significantly between the medical patients and the surgical patients (11.4% vs. 10.3%, $P=0.724$). Although age, body weight, and s-alb did not show any significant differences between the two groups (SGA A+B vs. SGA C), BMI of the SGA C groups was significantly lower than that of the SGA A+B group (20.7 ± 3.2 kg/m² vs. 23.1 ± 3.1 kg/m², $P<0.0001$) (Table 2).

1. Evaluation of the current nutrition screening tool

Based on the nutrition screening criteria, the majority of the patients were at low risk ($n=390$, 89.7%), whereas 37 patients

Table 3. Distribution of the diagnosis of the patients in the development phase

Diagnosis	Department		All
	Internal medicine	Surgery	
Cancer			
Gastrointestinal	114	94	208
Hepatobiliary	56	8	64
Thyroid	0	18	18
Breast	0	14	14
Others	2	3	5
Gastrointestinal disease	13	28	41
Hepatobiliary disease	14	14	28
Non-cancer			
Kidney disease	0	1	1
Respiratory disease	2	0	2
Others	1	5	6
Total	202	185	387

Table 2. General characteristics

Variable	Evaluation phase		Development phase	
	PG-SGA (A+B) (n=425)	PG-SGA C (n=10)	PG-SGA (A+B) (n=345)	PG-SGA C (n=42)
Age (y)	58.5 ± 12.0	58.9 ± 9.7	57.0 ± 13.5	61.2 ± 11.3
Gender (male:female)	237:188 (56:44)	6:4 (60:40)	191:154 (55:45)	24:18 (57:43)
Internal medicine:surgery	-	-	179:166 (52:48)	19:23 (55:45)
Height (cm)	163.6 ± 7.8	163.7 ± 10.2	163.1 ± 8.3	161.0 ± 8.4
Weight (kg)	62.2 ± 10.3^1	54.9 ± 10.9	61.1 ± 10.8	59.4 ± 10.6
BMI (kg/m ²)	23.2 ± 2.9^1	20.0 ± 3.1	23.1 ± 3.1^1	20.7 ± 3.2
s-alb (d/dL)	4.22 ± 0.39	4.00 ± 0.39	3.85 ± 0.57	3.77 ± 0.64
Length of stay (d)	10.2 ± 4.0	10.2 ± 2.6	7.5 ± 6.4	9.2 ± 8.8

Values are presented as mean \pm standard deviation or number.

¹Significantly different from the severely malnourished patients ($P<0.05$).

PG-SGA = patient-generated subjective global assessment; BMI = body mass index; s-alb = serum albumin.

(8.5%) were at moderate risk and 8 patients (1.8%) at high nutritional risk (Table 4). The correlation between the PG-SGA and the current nutrition screening tool was poor, with $\kappa = 0.180$ ($P < 0.0001$; Table 4), which indicated the necessity of developing a new nutrition screening tool to improve specificity and sensitivity.

2. Development of Severance nutrition screening index

We reviewed the candidate variables which are used in the nutrition screening tools in the PG-SGA, NRS 2002, NRI, and MNA for SNSI. Variables were required to be simple and quick to administer; use routinely available data; and minimise incomplete screening due to missing data. Age, disease severity, weight loss, intake change, BMI, and s-alb, which satisfied the selection criteria, were chosen for multiple logistic regressions. Multiple logistic regression identified significant explanatory variables in nutritional status, such as decreased food intake

(odds ratio [OR], 75.8; 95% confidence interval [CI], 9.63 ~ 595.69; $P < 0.0001$), weight loss (OR, 4.15; 95% CI, 1.36 ~ 12.65; $P = 0.012$), s-alb (OR, 3.97; 95% CI, 1.37 ~ 11.50; $P = 0.011$), and BMI 2.82 [0.86 ~ 9.25], $P = 0.088$; Table 5).

The SNSI was calculated as described in Table 6. Intake change was scored as 1 (no change or increase in intake) or 2 (decrease). Weight loss was determined using the previous month's weight as the base and scored as 1 (no change, increased or decrease $< 5\%$ of usual body weight) or 2 (decrease $\geq 5\%$). S-alb was scored as 1 (≥ 3.5 g/dL) or 2 (< 3.5 g/dL) and BMI as 1 (≥ 20 kg/m²) or 2 (< 20 kg/m²). A SNSI score no less than 13.5 was set as the cut-off score for malnutrition risk based on sensitivity and specificity levels against PG-SGA (Table 6).

3. Validity of the SNSI

When the SNSI cut-off point for malnutrition was set as the highest score (Youden's index=0.822), there were 70 high nu-

Table 4. Comparison of the results of the current nutrition screening tool and PG-SGA

	PG-SGA			Total	κ
	A	B	C		
Nutritional risk					
Low	348 (89.2)	35 (9.0)	7 (1.8)	390 (100)	
Moderate	26 (70.3)	10 (27.0)	1 (2.7)	37 (100)	0.180
High	4 (50.0)	2 (25.0)	2 (25.0)	8 (100)	
Total	378 (86.9)	47 (10.8)	10 (2.3)	435 (100)	

Values are presented as number of subjects (%). Kappa value (κ) < 0.2 (poor), $0.2 \sim 0.4$ (fair), $0.4 \sim 0.6$ (moderate), $0.6 \sim 0.8$ (substantial), > 0.8 (perfect).

PG-SGA = patient-generated subjective global assessment.

Table 6. Model of the newly developed Severance nutrition screening index (SNSI)

Variable	Value
SNSI	Model=(1.5 s-alb)+(1.0 BMI)+(4.5 food intake change)+ (1.5 weight change)
Albumin (g/dL)	$\geq 3.5=1$, $< 3.5=2$
BMI (kg/m ²)	$\geq 20=1$, $< 20=2$
Food intake change	No change or increase=1, decrease=2
Weight change	No change, increase, or decrease $< 5\%$ of usual body weight=1, decrease $\geq 5\%=2$

s-alb = serum albumin; BMI = body mass index.

Table 5. Odds ratios (OR) of significant variables for patients-generated subjective global assessment from multiple logistic regression analysis

Variable	Regression coefficient (B)	OR (95% CI)	P-value		
			Step 1	Step 2	Step 3
Disease severity	0.189	1.00 (0.03 ~ 4.40)	0.999		
Age ≥ 65 years	0.045	1.08 (0.35 ~ 3.26)	0.907	0.899	
BMI < 20 kg/m ²	1.378	2.82 (0.86 ~ 9.25)	0.104	0.100	0.088
s-alb < 3.5 g/dL	1.035	3.97 (1.37 ~ 11.50)	0.013	0.012	0.011
% Weight loss	1.424	4.15 (1.36 ~ 12.65)	0.016	0.014	0.012
Decreased food intake	4.327	75.75 (9.63 ~ 595.69)	0.000	0.000	0.000

Explanatory variables: disease severity, age, BMI, s-alb, % weight loss, decreased food intake.

CI = confidence interval; disease severity = cancer, HIV, pulmonary or cardiac cachexia, gastrointestinal fistula, pressure sore, trauma, renal failure; BMI = body mass index; s-alb = serum albumin; % weight loss = weight loss of $\geq 5\%$ of usual body weight for the past 1 month or $\geq 10\%$ of usual body weight for the past 6 months; decreased food intake, decreased food intake for the past 1 week.

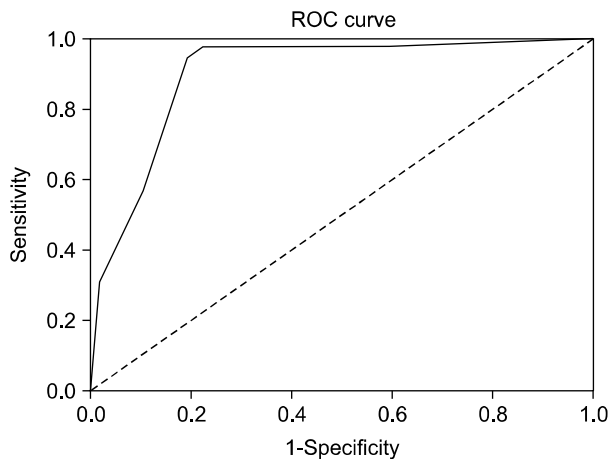


Fig. 1. Receiver operator characteristic (ROC) curve for the newly developed Severance nutrition screening index (SNSI) compared with patient-generated subjective global assessment. The 45° line represents a curve for a ROC area of 0.5. The area under the curve is 0.899 (95% confidence interval, 0.854~0.943) for the SNSI.

tritional risk patients (18.1%). ROC analysis for the cross-validity of the SNSI is presented in Fig. 1. The goodness of the SNSI model was checked with the area under the ROC curve for the SNSI compared with a PG-SGA of 0.899 (95% CI, 0.854~0.943), which showed high accuracy according to an arbitrary guideline. The sensitivity and specificity of the SNSI for the Scored PG-SGA (gold standard) were 90.5% and 90.7%, respectively. The relationship between the two methods was high, with $\kappa=0.628$ ($P<0.0001$, Table 7).

We determined the consistency between the two methods in the evaluation phase patients using κ statistics. The value of κ was increased from 0.180 to 0.347. The area of under the ROC curves was 0.711 (95% CI, 0.498~0.925), which showed fair accuracy according to an arbitrary guideline.

DISCUSSION

As the first step in a quality improvement program for the nutrition care process in a university hospital, a new nutrition screening tool (SNSI) was developed and validated for the screening of malnutrition in hospitalised patients. A number of nutritional screening and assessment tools have been developed to assess nutritional risk. Each tool has advantages and disadvantages. Many researchers have compared a large number of nutrition screening and assessment tools. Skipper et al.⁶ analysed the evidence to identify the most valid and reliable nutrition screening tools for use in acute care and hospital-based

Table 7. Validity of the newly developed Severance nutrition screening index (SNSI)

PG-SGA	SNSI		Total
	Low risk	High risk	
Well-nourished or moderately malnourished ¹	313 (90.7)	32 (9.3)	345 (100)
Severely malnourished ²	4 (9.5)	38 (90.5)	42 (100)
Total	317 (72.1)	70 (27.9)	387 (100)
Sensitivity	90.5		
Specificity	90.7		
Kappa value (κ)	0.628		

Values are presented as number (% or percent only). $P<0.0001$ for percentage of agreement between PG-SGA and SNSI at κ statistic.

¹PG-SGA stage A+B according to PG-SGA assessment, ²PG-SGA stage C according to PG-SGA assessment.

PG-SGA = patient-generated subjective global assessment.

ambulatory care settings. They reported that the malnutrition screening tool (MST) was the only tool that was shown to be both valid and reliable for identifying undernutrition. MST incorporates three components: presence of weight loss (score 0 or 2), amount of weight lost (score 1~4), and poor food intake or poor appetite (score 0 or 1).⁷ A score ≥ 2 means that the patients is at risk for malnutrition. Kyle et al.⁸ reported that the NRS 2002 had higher sensitivity and specificity than the MUST and NRI compared with the SGA. The European Society for Clinical Nutrition and Metabolism recommends the NRS 2002 to screen hospitalised adults.⁴ Because the NRS 2002 is based on anthropometrics, food intake, age, and metabolic stress, applying this tool to the identification of nutrition risk groups for all hospitalised patients is associated with large costs in terms of time and manpower. For Korean cancer patients, Kim et al.⁹ reported that the sensitivity and specificity of the NRI and NRS 2002 against the PG-SGA (gold standard) were 81.8%, 48.7% and 72.9%, 81.9%, respectively, and developed the malnutrition screening tool for cancer patients for the screening of malnutrition in hospitalised cancer patients with higher sensitivity (94.0%), specificity (84.2%), and kappa (0.7) value than those of the NRI (0.22) and NRS 2002 (0.5) against PG-SGA. As a 2,000-bed university hospital, we have patients with various diseases, not limited to cancer, and need a nutrition screening tool that can be used for all of our patients.

In this study, we improved the consistency between the result of nutrition screening and that of the PG-SGA from 0.180 to 0.628, as evaluated by kappa statistics. Whereas the current nu-

trition screening tool includes %IBW, s-alb and diagnosis, which are convenient in terms of speed and completion rate, i.e. minimising missing patients, but fail to represent nutritional stability and future risk of development of malnutrition. The SNSI includes changes in food intake, weight loss, BMI and s-alb as significant parameters through multiple logistic regression analysis. s-alb, % weight loss, changes in food intake and BMI all proved to be related to clinical outcomes such as length of stay (LOS), morbidity and mortality, whereas the level of associations with LOS was lower than that obtained with the SGA, NRI, MUST or NRS 2002, showing the superior value of these nutritional screening tools over single parameters.⁸ Knowing whether there has been recent weight loss over time helps to identify patients who are at risk for malnutrition, and this information seems to be the most important single indicator of nutritional status.¹⁰ Moreover, this finding suggests that nutritional screening tools should use both BMI and weight loss to predict risk for malnutrition.¹¹

Based on the SNSI, 18.1% of the patients were evaluated as high nutritional risk. The prevalence of malnutrition differs across tools and depends on the subject's characteristics. The nutrition screening tool should be selected considering the characteristics of the subject populations and the capability of the institutions, i.e. the personnel for nutrition screening and the nutrition care process for selected malnourished patients. Our hospital has 200 to 250 new patients every day and lacks clinical dieticians and we decided to select the patients who were at risk of severe malnourishment (SGA C). The purpose of nutritional screening is to identify those patients who are at nutritional risk and at higher risk for complications. Selecting the patients with established severe malnutrition or who are at risk of developing the condition is an more effective strategy in settings that lack clinical dieticians who can conduct nutritional intervention. Generally, approximately 15% of patients admitted daily are identified as being at moderate to high risk for malnutrition with the current nutrition screening tools. The increased prevalence of patients at high risk for malnutrition might be due to the practice of changes in weight and food intake prior to admission. In a study of mixed hospitalised patients in Singapore, 22.3% of the subjects were identified as being at risk of malnutrition with the MST; however, of those subjects, approximately 69% were confirmed to be malnourished.¹ In the EuroOOPS study, 32.6% of the 5,051 patients were defined as at-risk by the NRS 2002.¹² For Korean cancer patients, 26.1%

of 257 patients were classified as malnourished by another nutrition screening tool.⁹ Poulia et al.¹³ and Kyle et al.⁸ showed differences in the prevalence of malnutrition among nutrition screening tools even when applied to the same patients.

We used the Scored PG-SGA as the gold standard for development and validation of the SNSI. The SGA has been reported as an accurate nutrition assessment tool that is a predictor of complications, such as infections and poor wound healing, and is associated with longer LOS in severely malnourished patients.^{14,15} The SGA was developed to assess nutrition-associated complications, but Jeejeebhoy¹⁶ suggested that it could equally likely represent an index of sickness rather than nutrition. Furthermore, examiner training to improve competency in nutritional assessment may be necessary to obtain higher specificity and sensitivity with the SGA. Although trained clinical dieticians have conducted nutrition assessments using the PG-SGA, the SGA has some limitations as a reference assessment tool. Therefore, using the PG-SGA as a gold standard to develop and validate SNSI is a limitation of the present study. However, the PG-SGA is one of the best available tools for assessing nutrition status because it is patient centred, incorporates clinical history and physical examination, and has been demonstrated to be associated with patient outcome. Many studies on developing or validating nutrition screening tools used the PG-SGA as a gold standard, whereas some studies used the results of clinical nutrition assessments.^{6,17} In the clinical setting, nurses are more likely to perform such a survey about changes in weight and food intake; thus, it might be necessary to ensure consistency in the methods used by different investigators to evaluate the validity and reproducibility of the new nutrition screening tool.

CONCLUSION

In the present study, we developed a new nutrition screening index, the SNSI, for patients who were admitted to an acute care university hospital with various diseases. For the SNSI, % weight loss, decreased food intake, s-alb and BMI were selected as significant. Few studies directly link the nutrition process to improved outcomes. Further research is needed to evaluate the benefits of nutritional screening and intervention and their effect on outcomes in various disease populations.

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